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Vulnerability of Agriculture to Climate Shocks in Odisha, India

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Abstract
This paper explores the vulnerability of agriculture to climate shocks in Odisha, India and also shows the loss of agricultural crops and productivity due to extreme climate events like droughts, floods and cyclones. Climate change and climate shocks affect different sectors, and livelihoods of population differently depending on the adaptive capacity. Using secondary data, the study analyses the agricultural vulnerability to the increasing climate shocks and present a historical picture of climate shocks that took place in the state of Odisha during last few decades. It is observed that climate shocks are increasing and it is affecting agriculture sector to a large extent leading to the vulnerability of agricultural dependent communities. Analyzing the vulnerability of agriculture to climate shocks, the study also explored the possibility to adapt the shocks and suggested some adaptation strategies to reduce the agricultural vulnerability.
Keywords: Climate Change, Vulnerability, Agriculture

1. Introduction

Agriculture is the most important occupation and considered as the backbone of the Odisha economy. Agriculture is the state's dominant sector after Service sector with a contribution of nearly 22 per cent to the Net State Domestic Product (NSDP). Though the contribution of agriculture to NSDP has significantly declined, it still provides employment and livelihood directly or indirectly to more than 60 percent of the state's total work force (Economic Survey, 2013). As more than 70 percent work force is still engaged in agriculture for its livelihood and a majority of low income, poor and vulnerable sections of society depends on agriculture, the economic progress of the state depend on agriculture to a considerable extent. Therefore the economic fortunes of large majority of people in the study area are basically linked with agricultural performance. Agriculture growth has direct impact on poverty eradication, raising agricultural wages and employment generation. Therefore a rapid growth in agriculture that leads to increased productivity and income of a large number of cultivators and agriculture labourers is an important vehicle for accelerating growth through forward, backward and consumption linkages in the study areas.

Several studies on agriculture have pointed out that Green Revolution has contributed to the growth in production and productivity. Some researchers concluded that through wide spread adoption of modern input and improved production practices the instability of agriculture caused by weather has reduced considerably (Hazell, 1982). On the other hand some argued that much of the alarming instability in agriculture is due to the widespread adoption of modern technologies (Mehra, 1981; Ray, 1983). Some literature pointed out that although instability affects both production and productivity but it can't be solely attributed to climatic factors, could be man-made and can be reduced by human action. Rao et al (1988) identified sensitivity of crop output and the unstable agriculture is due to rainfall and erratic irrigation facility.

But the predicted climate change in the study areas in terms of decreasing rainfall, increasing temperature, falling relative humidity, and increasing threat of climate shocks are doubling the vulnerability of agriculture in the study areas. The predicted climate may alter the distribution and quality of natural resources including agriculture and adversely affect the economy and livelihood of the people. With an economy closely tied to its natural resource base and climate-sensitive sectors such as agriculture, water and forestry, the state may face a major treat because of the projected climate change. Further, with advance in global warming and climate change, if sea storms acquire greater destructive power as is being forecast, the Odisha will be required to bear the burden of such storms which means devastating effects on livelihoods, ecology and economy. Thus, the uncertainties associated with agriculture in Odisha are attributed to natural phenomena such as erratic monsoon, flood, cyclone or drought. The issue of sustaining agriculture on a self-reliant manner is at stake. Therefore, proper understanding of the implication of climate variability on agriculture is required for formulating appropriate strategy to deal with the negative implication. Here, an attempt is made to provide a clear cut ideas related to growth, instability and production variability in agriculture in the study area. This is intended to trace out the existing performance of agriculture in the study areas and then we tried to find out the loss in agriculture due to climatic factor.

2. Study area and Data used

In the above background an attempt has been made to explore the agricultural performance in Odisha during last 45 years (1970-2014) in the state of Odisha. Area wise Odisha is the ninth largest state of India, with an area of 1, 55,842 Sq. Km. It is one of the coastal states of India lies on the eastern seaboard of India with 480 Km. long coastline. Geographically Odisha is located between 17 49′ to 22 36' North latitudes and 81 36' to 87 18' East longitudes. Physiographically the state is broadly divided into four Zones namely Coastal Plains, Central Table Land, Northern Plateau and Eastern Ghats. Further it is sub-divided into 10 Agroclimatic Zones namely North Western Plateau, North Central Plateau, North Eastern Coastal Plain, East and South Eastern Coastal Plain, North Eastern Ghat, Eastern Ghat High Land, South Eastern Ghat, Western Undulating Zone, Western Central Table Land and Mid Central Table Land. The climatic condition of the state is influenced by the sea as it is located on the east coast belt. The region is represented by tropical climate with high temperature, humid weather, medium to high rainfall and short and mild winters. South-west monsoon is the major contributors (80%) of the annual rainfall and the state has annual average rainfall of 150 cm with 100cm to 198cm variation across the state. The average annual temperature of the state is 26.89˚C with a wide variation in the average annual maximum and minimum temperature. Further the state is characterized by fragile environment, prone to drought, flood and cyclone, low and highly variable rainfall. A majority of population (82%) of the state live in rural areas and agriculture is the main occupation of the people. Natural calamities such as cyclones, droughts, and floods occur almost every year with varying intensity which is negatively affecting the agricultural production in the state. Therefore it is imperative to study the climate factors in the state to understand their impact on the growth in agriculture and socio-economic development of the state.

Data Used

To accomplish the objectives of the study, data on the agricultural variables span the time period 1970-2014 have been collected from the ICRISAT VDSA (Village Dynamics in South Asia) Apportioned Meso database. Climate related variables data are collected from IMD pune, various issues of Odisha agricultural statistics.

3. Performance of Agriculture Output in Odisha during the Period 1970-2014

Agriculture plays a dominant role in the economy of Odisha with contribution of more than 20% to Net State Domestic Product. Agriculture is the main stay of the State and the performance of the agriculture output determines the characteristics of the State economy and further the analysis of performance of agriculture output will make us understand the status, determinates, issues and problems of agriculture in the study area.

3.1. Average Output and Yield of Major Corps during 1970-2014

During last four and half decades the performance of the agriculture in Odisha has been highly skeptical as the growth performance of major crops has been very unstable and erratic. Five yearly average of production and yield of 12 crops such as rice, wheat, maize, cereals, chickpea, pigeonpea, pulses, groundnut, sesame, rape and mustard, oilseeds and sugarcane are shown in table 1 which reveals that rice and cereals are the most important major crops produced in Odisha besides other crops. Rice production has increased continuously during 1970-2014. The average rice production and yield during 1970-74 were 3751.8 thousand metric tons and 833.9 Kg./hect which increased to 3886.7 thousand metric tons and 882.7 Kg./hect respectively during 1974-79. Similarly, the average rice production and yield during 1980-84 were 4087.6 thousand metric tons and 987.7 Kg./hect which became 5489.2 thousand metric tons and 1217.4 Kg./hect during 1995-99 and further became 7096.8 thousand metric tons and 1598.4 Kg./hect respectively during 2005-09. During 2010-14 the average rice production and yield were 6769.2 thousand metric tons and 1575.8 Kg./hect.

Table 1 Average Output and Yield of Major Corps during 1970-2014

Crops	1970-74		1975-79		1980-84		1985-89		1990-94		1995-99		2000-04		2005-09		2010-14	
	P	Y	P	Y	P	Y	P	Y	P	Y	P	Y	P	Y	P	Y	P	Y
Rice	3751.8	833.9	3886.7	882.7	4087.6	987.7	5010.5	1159.8	6058.6	1350.6	5489.2	1217.4	5655.4	1267.9	7096.8	1598.4	6769.2	1575.8
Wheat	59.5	1498.6	105.8	1758.9	116.1	1890.8	81.4	1800.9	44.8	1719.2	25.4	1433.0	22.7	1332.4	27.6	1469.1	25.9	1607.2
Maize	63.0	736.8	107.2	844.3	174.7	1103.4	181.8	1103.1	190.9	1104.7	202.1	1224.4	204.0	1184.7	418.9	1964.9	498.2	2035.2
Cereals	4254.9	842.5	4372.0	854.5	4807.5	952.5	5595.5	1132.5	6554.1	1305.9	5897.5	1188.0	6045.5	1236.5	7717.9	1579.0	7439.0	1564.4
Chickpea	13.3	558.5	16.8	471.8	26.7	598.3	26.5	611.5	22.5	613.3	19.5	589.5	16.5	622.8	26.2	673.4	28.5	712.2
Pigeonpea	27.8	529.1	29.2	477.2	76.2	682.0	100.8	672.5	127.5	770.7	88.6	615.2	89.6	666.4	109.8	814.2	127.9	802.5
Pulses	449.8	490.2	594.7	446.4	955.4	536.7	1077.1	554.2	1126.7	534.5	747.4	431.1	581.9	374.1	905.0	456.3	979.4	458.9
Groundnut	111.2	1272.8	142.6	1123.9	345.0	1379.7	512.0	1407.6	489.6	1400.3	334.4	1218.5	293.4	1330.8	401.5	1656.4	466.3	1572.2
Sesamum	47.1	487.2	57.2	405.2	101.7	467.2	144.3	502.4	158.0	451.4	113.1	366.0	74.5	296.0	114.4	376.3	119.2	383.4
Rape and mustard	30.9	456.6	45.4	405.8	64.0	467.4	69.7	505.7	82.2	506.9	49.4	393.8	30.7	298.3	41.1	384.2	51.2	403.5
Oilseeds	260.7	694.8	317.3	567.3	621.0	709.8	815.2	763.7	853.9	756.4	584.2	620.2	452.3	593.7	629.7	763.0	721.1	776.8
Sugarcane	213.8	6056.0	280.1	6222.5	318.7	6453.8	318.4	6878.4	306.3	6903.4	297.3	6641.5	192.8	6447.3	266.7	7015.3	284.2	7207.7

Sources: Calculated various issues of Odisha Agricultural Statistics

Note: P = Production in '000mts; Y=Yield in Kg./hect

Wheat is another important crop which shows very discouraging results as its production is declining along with a highly erratic yield rate. During 1970-74 the average wheat product were 59.5 thousand metric tons which increased to 116.1 thousand metric tons during 1980-84 but there after it continuously decreased and during 2010-2014 it became 25.9 thousand metric tons only. As far as wheat yield is concerned it was 1498.6 Kg./hect during 1970-74 which increased to 1758.9 Kg./hect during 1975-79 and became 1800.9 Kg./hect during 1985-89 but thereafter continually decreased and became 1469.1 Kg./hect during 2005-09 and then increased to 1607.2Kg./hect during 2010-14. This shows a very erratic behavior of yield rate which is a matter of concern. The erratic yield rate and decline in average wheat production may be attributed to different factors including climatic factors and this requires a special investigation.

Maize average production and yield rate show encouraging results as both the production and yield rate have increased over the period 1970-2014. The average production and yield of the maize were 63 thousand metric tons and 736.8 Kg./hect during 1970-74 which increased to 181.8 thousand metric tons and 1103.1 Kg./hect during 1985-9-89 and then further increased continually and became 498.2 thousand metric tons and 2035.2 Kg./hect respectively during 2010-14. Similarly, cereals production and yield rate show increasing tendency during 1970-2014.

Besides the above crops, other crops like Chickpea, Pigeonpea, Pulses, Groundnut, Sesamum, Rape and mustard, Oilseeds and Sugarcane show very distressing picture about the status of crop production and yield rate. This is because the average production of Chickpea, Groundnut and Sugarcane show continuous declining tendency after 1985-89 where as average production of Pigeonpea, Pulses, Sesamum, Rape and mustard, and Oilseeds show continuous declining tendency after 1990-94. Similarly the yield of these crops either show declining tendency or show erratic behavior. The declining production and erratic yield rate of the above crops is a matter of great concern for the state economy as agriculture is the main stay of the Odisha's economy. A proper understanding of the above crop production status is required to explore the appropriate strategy. Therefore, to explore further we have calculated the growth rate and instability for above crop which is enlightened in the following subsections.

3.2. Growth Rates in Area, Production and Yield of Major Crops in Odisha

Understanding agricultural growth in Odisha is crucial not only to the concerns of farmers but also to the overall economic development of the State. The growth of production of crops depends on various factors such as growth of area, yield, irrigation facilities, farm mechanization, fertilizer used, and use of high yielding seeds. However, the major sources of growth of production are attributed to growth in area and yield. Table 2 shows compound annual growth rate in production of major crops which is decomposed into growth rate in area and yield of the crops during 1970-2014.

It is evident from table-2 that wheat, rape and mustard and sugarcane production have registered negative growth rate during 1970-2014. Wheat production have registered a negative compound growth rate of -3.62%, rape and mustard registered negative growth rate of -0.02% and sugarcane (Gur) registered negative growth rate

of -0.03%. The negative growth rate in wheat production is attributed to both negative growth rate in area (-3.22%) and yield (-0.40%) while negative growth rate in rape and mustard is exclusively attributed to the decline in yield rate by -0.61%. On the other hand the negative growth rate in sugarcane (Gur) production is due to decline in area (-0.36%) under cultivation though its yield rate have shown a positive growth rate (-0.34%) during 1970-2014. As far as decadal annual compound growth rate is concerned wheat production growth rate were highest (15.97%) during 1970-79 due to high growth rate in area (13.62) and yield rate (2.07). But later on during the decades 1980-89, 1990-99 and 2000-2009 the wheat production registered a negative growth rate which is also attributed to the negative growth rate in area and yield. Similarly rape and mustard and sugarcane have also registered negative compound growth rate during the decade 1990-99 and in other decades the growth rate were very negligible.

It is very interesting to observe that all the crops have registered a negative growth rate in area, production and yield during the decade 1990-99. This is the worst performing period for agriculture in the state of Odisha during last four and half decades. During 1970-79 all the crops except rice and cereals have registered positive compound growth rates in production due to positive growth rate in area under cultivation in spite of negative growth rate in yield rate. Similarly during 1980-89 all the crops except wheat have registered positive compound growth rate in production due to positive growth rate in yield though crops like cereals, chickpea, rape and mustard and sugarcane have registered negative growth rate in area under cultivation.

Table 2 Compound Annual Growth rate of Area, Production and Yield of Major Crops during 1970-2014

Crops	1970-1979			1980-1989			1990-1999			2000-2009			2010-2014			1970-2014		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Rice	-0.57	-0.38	0.19	0.81	3.97	3.14	-0.10	-1.29	-1.19	-0.03	4.96	4.99	1.84	2.19	0.34	-0.02	1.63	1.65
Wheat	13.62	15.97	2.07	-6.52	-7.44	-0.98	-7.23	-10.53	-3.55	2.23	4.23	1.96	-1.32	-2.19	-0.89	-3.23	-3.62	-0.40
Maize	7.83	8.41	0.54	0.05	0.91	0.85	-0.33	1.23	1.57	3.97	13.72	9.38	-2.44	-11.86	-9.66	1.96	4.27	2.27
Cereals	-0.05	-0.82	-0.77	-0.43	2.96	3.40	-0.14	-1.49	-1.35	0.05	5.22	5.17	1.48	0.95	-0.52	-0.14	1.49	1.63
Chickpea	8.34	4.94	-3.13	-0.33	0.22	0.55	-2.31	-4.10	-1.83	7.95	9.53	1.46	-0.78	-4.84	-4.09	0.37	1.04	0.67
Pigeonpea	3.66	0.87	-2.69	6.58	8.06	1.39	-2.63	-6.54	-4.02	-0.21	3.46	3.67	7.83	3.31	-4.19	2.45	3.53	1.05
Pulses	7.71	5.03	-2.49	1.48	1.90	0.41	-3.94	-7.89	-4.12	4.55	8.14	3.43	2.28	0.81	-1.43	1.41	1.01	-0.39
Groundnut	9.10	5.97	-2.87	8.35	8.84	0.45	-5.07	-6.89	-1.91	2.06	6.88	4.72	9.03	5.00	-3.69	2.17	2.79	0.61
Sesamum	7.20	2.86	-4.05	6.41	7.80	1.31	-2.81	-7.14	-4.46	4.35	8.37	3.85	11.16	9.64	-1.37	2.47	1.65	-0.80
Rape and mustard	10.75	7.00	-3.38	-1.00	0.06	1.07	-5.18	-10.33	-5.43	1.28	5.12	3.79	5.74	5.20	-0.51	0.60	-0.02	-0.61
Oilseeds	8.90	4.27	-4.26	4.52	5.95	1.37	-3.80	-7.21	-3.55	1.75	6.70	4.86	10.07	5.56	-4.10	1.50	1.75	0.25
Sugarcane	5.35	5.81	0.44	-1.05	0.20	1.26	-1.94	-3.12	-1.20	3.91	5.37	1.41	-0.73	-0.26	0.47	-0.36	-0.03	0.34

Source: Calculated by Author
Note: A= Area; P = Production; Y=Yield

Further during the decade 2000-2009 all the crops have shown positive growth rate in area, production and yield while only rice and Pigeonpea have registered negative growth rate in area under cultivation. During the period 2010-2014 all the crops except rice and sugarcane have registered negative growth rate in yield having concomitant effects on the growth rate of production.

Thus it is quite clear that the growth rates of agricultural products have been highly skeptical and irregular in Odisha. This is due to either decline in yield rate or decline in area under cultivation. Further the yield rates of various crops have been highly erratic which may be attributed to bad weather, natural calamities or factors specific to the local area. So, a proper understanding of the change in crop production, area and yield is required to draw a balanced conclusion. Therefore in the following section we have analysed the instability in area, production and yield of the above 12 crops produced in Odisha.

3.3. Instability in Area, Production and Yield of Major Crops in Odisha

Instability in agriculture may be attributed to many factors including climate change. Therefore Instability in the area, production and yield of the major crops are calculated to understand the agricultural variation in Odisha during 1970-2014 which is presented in table-3.

It is evident from table -3 that the instability in the production of all most all major crops were found to be high during 1970-2014. The instability were highest in the production of sesame (29.76%) followed by rice production (28.21%) and mustard production (27.37%) during 1970-2014. However, the instability was found to be least (14.26 %) in the sugarcane production during 1970-2014. Similarly the instability in area and yield found to be highest for wheat and rice respectively during 1970-2014.

During the period 1970-79 instability was highest in rape and mustard production (40.44%) followed by wheat (38.41%) and peagonpea production (30.78%). Further the instability in rice, maize, cereal, chickpea, pulses,

groundnut, Sasemum, oilseed and sugarcane production were 29.63%, 32.13%, 30.03%, 25.16%, 28.84%, 28.45%, 29.84%, 27.35% and 9.13% respectively. Similarly during the period the instability in area under cultivation was highest for wheat (34.89%) followed by rape and mustard (25.07%). The groundnut yield rate has shown highest instability (32.09%) during 1970-79 followed by sesamum (30.86%) and maize (29.38%). During the period the instability in the yield rate of rice, wheat, cereals, chickpea, peagonpea, pulses, rape and mustard, oilseed, and sugarcane were 26.18%, 13.38%, 25.76%, 13.98%, 20.01%, 21.86%, 25.69% , 25.94% and 5.17%.

During the period 1980-89 the instability in rice production and yield was highest with instability index 29.83% and 22.58% respectively. Similarly during the period the instability in area under cultivation was highest for the sugarcane (17.89%) followed by rape and mustard crop (14.31%). On the other hand oilseeds have registered relatively lower instability index in production (8.73%) and yield (4.64%) during the period while Cereals, have registered lowest instability index in area under cultivation (5.37%).

Further during the period 1990-99, all the crops except maize have registered more than 20% instability index value in the production while their instability index value in yield were reasonably lower except for groundnuts and sasemum crops. Groundnuts and sasemum have registered 22.19% and 22.28% instability index value in their yield rates during the period 1990-99. Similarly, rice, cereals and groundnuts have registered relatively lower instability index value in area under cultivation while chickpea, wheat and rape & mustard have registered relatively higher instability in area under cultivation during 1990-99.

It is disturbing to observe that during the period 2000-2009 the instability in production of rice, cereals, sesamum and oilseeds have increased over previous periods. Rice, cereals, sesamum and oilseeds have registered 38.86%, 36.38%, 40.05 and 25.93% instability index value respectively during 2000-09 which is relatively higher instability over any other sub-period under study. The higher instability in the production of rice and cereals is attributed to higher instability in the yield of the respective crops while the higher instability in oilseeds is attributed to higher instability in area under cultivation of the crop.

Thus it is observed from the above that the instability in area, production, and yield of major crops are prevailing in different intensities in Odisha. The instability in the above major crops may be attributed to many factors including climate change and climate shocks. This is because we have observed in the earlier section that climate change is happening in Odisha in terms of change in rainfall pattern, and rise in temperature which is increasing the chances of climate shocks. Thus climate change and its related effects may have influenced the instability of crop production and yield in Odisha. Therefore a proper understanding of the implication of climate change on agriculture is required to address the climate change related issues in agriculture in Odisha.

Table 3 Instability in Area, Production and Yield of Major Crops in the Study Areas

Crops	1970-1979			1980-1989			1990-1999			2000-2009			2010-2014			1970-2014		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Rice	4.67	29.63	26.18	9.18	29.83	22.58	2.55	21.18	19.73	2.76	38.86	36.39	6.24	13.22	7.33	5.30	28.21	24.84
Wheat	34.89	38.41	13.38	6.44	10.58	6.44	17.09	21.24	8.28	19.28	20.46	2.65	14.15	9.64	4.56	22.30	25.29	8.26
Maize	23.47	32.13	29.38	12.76	14.30	8.96	6.14	12.95	14.42	5.67	16.49	12.69	7.65	20.64	13.66	13.54	20.67	17.52
Cereals	5.24	30.03	25.76	5.37	26.47	21.58	2.63	20.28	18.63	2.73	36.38	33.88	5.46	10.82	5.96	4.13	26.66	23.60
Chickpea	14.84	25.16	13.98	13.55	12.41	14.26	19.91	24.88	12.10	19.86	22.44	4.68	4.09	6.72	6.48	17.10	21.36	11.27
Pigeonpea	13.75	30.78	20.01	9.57	18.26	14.42	12.21	22.74	11.84	9.77	13.42	4.67	8.57	8.20	5.98	11.32	21.04	13.19
Pulses	12.68	28.84	21.86	13.40	14.03	6.47	15.05	26.51	11.84	14.35	21.14	7.90	4.89	6.07	1.95	13.40	22.22	12.55
Groundnut	8.32	28.45	32.09	9.00	13.39	8.83	6.28	24.13	22.19	12.35	24.43	13.23	11.42	4.43	7.19	10.81	22.57	19.57
Sesamum	17.04	29.84	30.86	10.38	18.13	10.42	15.11	32.00	22.28	31.45	40.05	13.18	21.70	16.71	5.22	19.88	29.76	19.35
Rape and mustard	25.07	40.44	25.69	14.31	19.24	10.82	17.13	26.85	14.71	16.07	23.16	10.42	6.06	10.74	7.14	17.96	27.37	15.55
Oilseeds	11.16	27.35	25.94	7.76	8.73	4.64	9.14	23.93	16.31	17.32	25.93	9.85	15.19	5.76	9.80	12.63	21.95	15.46
Sugarcane	9.16	9.13	5.17	17.89	13.44	5.36	17.05	20.80	7.69	10.44	14.05	4.11	2.90	2.45	0.46	13.42	14.26	5.31

Source: Calculated by Author
Note: A= Area; P = Production; Y=Yield

4. Climate Change and Odisha

Climate impact studies have consistently predicted extensive impacts on the economy across the globe. With an economy closely tied to its natural resource base and climate-sensitive sectors such as agriculture, water and forestry Odisha may face a major treat because of the projected climate change. Odisha is one of the coastal states of India and is in the path way of depressions and cyclones formed in the Bay of Bengal during south west monsoon. Thus Odisha is frequently bearing the destructive effects of these natural calamities. Further, with advance in global warming and climate change, if sea storms acquire greater destructive power as is being forecast, the state

will be required to bear the burden of such storms which means devastating effects on livelihoods, ecology and economy of the state. So given the potential threat of climate change the following section investigates the change in climate variables and its impact. This will enable us to understand the climate change dynamics in the state.

4.1. Vulnerability of Agriculture to climate shocks in Odisha

The State of Odisha is located between the parallels of 17.49'N and 22.34'N latitudes and meridians of 81.27'E and 87.29'E longitudes. It is bounded by the Bay of Bengal on the east. It has a coast line of about 450 kms. It extends over an area of 155,707 square km accounting about 4.87 of the total area of India. Nearly 85% of people live in rural areas and depend mostly on agriculture for their livelihood. Agriculture plays a dominant role in the economy of the state with contribution of more than 20% to Net State Domestic Product. But in Odisha the agriculture is largely rainfed. The normal rainfall of the state is 1451.2mm of which 75-80% is received from June to September by the impact of South-West monsoon. But the economic history of Odisha is a story of ravages of the recurrent floods, cyclones and droughts that have created and still creating havoc in the economic and social life of the people of the State. These climate shocks are the crucial factors that have pushed back the progress of the economy. The loss of the economics values in agriculture sector is shown in the Table No. 1.

4.1.1. Floods

Before draining into the Bay of Bengal, all the major rivers of Odisha flow long distances. The drainage system with low channel capacity, low flood slope, sand banked mouths, high concentration of rainfall in a small number of days in the catchments basin are contributing to factors for flood in Odisha. The frequent occurrence of flood and the damage associate with it is observed from the Table No. 1.

4.1.2. Droughts

Like flood, drought is recurrent in Orissa. In most of the years, droughts and floods are experienced simultaneously because of excessive rainfall in some parts of the catchment basins and low rainfall in other regions. Just like floods, droughts wreak in a lot of suffering to the Orissa people the damages being overwhelming by nature. Every alternate year, either a drought or flood has become a recurring phenomenon in the State. The occurrence of the climate shocks in the State during last 15 years is indicated Table 4.

Table 4: Climate shocks and loss of Rice Production in the State

Sl.No.	Year	Normal Rainfall mms	Actual rainfall mms	Actual minus Normal	Kharif Rice Production (lakh MT)	Remarks
1	1961	1502.5	1262.8	-239.7	36.99	Normal year
2	1962	1503	1169.9	-332.6	36.32	Normal year
3	1963	1503	1467	-35.5	42.47	Normal year
4	1964	1503	1414.1	-88.4	43.59	Normal year
5	1965	1503	997.1	-505.4	31.89	Severe drought
6	1966	1503	1134.9	-367.6	35.37	Drought
7	1967	1503	1326.7	-175.8	34.43	Cyclone & Flood
8	1968	1503	1296.1	-206.4	38.48	Cyclone & Flood
9	1969	1503	1802.1	299.6	38.39	Flood
10	1970	1503	1660.2	157.7	39.13	Flood
11	1971	1503	1791.5	289	33.76	Flood, Severe Cyclone
12	1972	1503	1177.1	-325.4	37.35	Drought, flood
13	1973	1503	1360.1	-142.4	41.91	Flood
14	1974	1503	951.2	-551.3	29.67	Flood, severe drought
15	1975	1503	1325.6	-176.9	42.74	Flood
16	1976	1503	1012.5	-490	29.58	Severe drought
17	1977	1503	1326.9	-175.6	40.5	Flood
18	1978	1503	1261.3	-241.2	41.89	Tornados, hail storm
19	1979	1503	950.7	-551.8	27.34	Severe drought
20	1980	1503	1321.7	-180.8	40.31	Flood, drought
21	1981	1503	1187.4	-315.1	36.63	Flood, drought, Tornado
22	1982	1503	1179.9	-322.6	27.07	High flood, drought, cyclone
23	1983	1503	1374.1	-128.4	47.63	Normal year
24	1984	1503	1302.8	-199.7	38.5	Drought
25	1985	1503	1606.8	104.3	48.8	Flood
26	1986	1503	1566.1	63.6	44.56	Normal year
27	1987	1503	1040.8	-461.7	31.03	Severe drought
28	1988	1503	1270.5	-232	48.96	Normal year
29	1989	1503	1283.9	-218.6	58.4	Normal year
30	1990	1503	1865.8	363.3	48.42	Flood

Table 4: Climate shocks and loss of Rice Production in the State						
Sl.No.	Year	Normal Rainfall mms	Actual rainfall mms	Actual minus Normal	Kharif Rice Production (lakh MT)	Remarks
31	1991	1503	1465.7	-36.8	60.3	Normal year
32	1992	1503	1344.1	-158.4	49.76	Flood, drought
33	1993	1503	1421.6	-80.9	61.02	Normal year
34	1994	1503	1700.2	197.7	58.31	Normal year
35	1995	1503	1588	85.5	56.48	Normal year
36	1996	1503	990.1	-512.4	38.27	Severe drought
37	1997	1503	1493	-9.5	57.51	Normal year
38	1998	1503	1277.5	-225	48.85	Severe drought
39	1999	1503	1435.7	-66.8	42.75	Severe Cyclone
40	2000	1502.5	1035.1	-467.4	41.72	Drought & Flood
41	2001	1482.2	1616.2	134	65.71	Flood
42	2002	1482.2	1007.8	-474.4	28.26	Severe drought
43	2003	1482.2	1663.5	181.3	61.99	Flood
44	2004	1482.2	1273.6	-208.6	58.84	Moisture stress
45	2005	1451.2	1519.5	68.3	62.49	Moisture stress
46	2006	1451.2	1682.8	231.6	61.96	Moisture stress/Flood
47	2007	1451.2	1591.5	140.3	68.26	Flood
48	2008	1451.2	1523.6	72.4	60.92	Flood , Moisture Stress
49	2009	1451.2	1362.6	-88.6	62.93	Flood/ Moisture stress/ Pest attack.
50	2010	1451.2	1293	-158.2	60.51	Drought/ Un-seasonal rain
51	2011	1451.2	1327.8	-123.4	51.27	Flood/ Drought
52	2012	1451.2	1391.3	-59.9	86.81	Drought in Balasore, Bhadrak, Mayurbhanj & Nuapada districts
Source: Status of Agriculture in Odisha, Directorate of Agriculture, Odisha						

Table 4 reveals that out of 52 years only 13 years have been normal years and in all other years the state has bear the impact of climate shocks .This almost puts the state with a 75% probability of being visited by these climate shocks of any kind. Further it is also observed that there is consistent loss of rice productions because of these events. The table 5 reveals more pathetic results of these climate shocks.

Table-5 Impact of Climate Shocks							
Year	Nature of Calamities	No. of Districts affected	No. of Blocks affected	No. of Villages Affected	Cropped area affected (Lakh Ha)	Loss of Human Life	Remarks
1999	Super Cyclone	12	97		17.86	9866	15.8 lakhs houses damaged
2000	Drought	29	216	16857	10.69		
2001	Flood	28	219	18790	7.16	102	
2002	Flood	29	290	32603	28.46		
2003	Flood	23	128	6846	9.17	92	
2004	Flood	5	20	564	0.37	10	
2005	Flood	14	72	4228	0.94	19	
2006	Flood	27	245	18912	4.65	105	
2007	Flood	15	100	5677	3.18	91	
2008	Flood	21	157	9265		110	2.85 lakh houses damaged
Source: SRC, Odisha							

Table 5 reveals that the economic loss is huge interms of cropped area affected and the loss of human life. A district wise analysis of crop area affected due to climate shocks are given in table No.6

Table 6 District wise maximum area affected during 2001-2008

Sl. No.	District	Maximum Area affected by flood (in '000 ha) (from 2001-2008)		
		Paddy	Non-Paddy	Total
1	Balasore	71.35 (2007)	6.81 (2007)	78.16
2	Bhadrak	60.62 (2003)	3.13 (2005)	63.75
3	Bolangir	22.68 (2001)	6.39 (2001)	29.07
4	Sonepur	28.53 (2001)	2.52 (2001)	31.05
5	Cuttack	80.59 (2001)	13.87 (2008)	94.46
6	Jagatsingpur	66.23 (2001)	5.30 (2001)	71.53
7	Jajpur	56.18 (2001)	7.44 (2003)	63.62
8	Kendrapara	58.39 (2001)	11.84 (2006)	70.23
9	Dhenkanal	4.69 (2001)	1.85 (2001)	6.54
10	Angul	11.10 (2001)	10.47 (2001)	21.57
11	Ganjam	56.01 (2003)	17.10 (2003)	73.11
12	Gajapati	1.14 (2003)	0.71 (2006)	1.85
13	Kalahandi	67.97 (2001)	15.25 (2001)	83.22
14	Nuapada	15.35 (2001)	0.61 (2008)	15.96
15	Keonjhar	2.09 (2003)	0.98 (2003)	3.07
16	Koraput	7.54 (2001)	7.61 (2001)	15.15
17	Malkangiri	3.85 (2006)	1.53 (2006)	5.38
18	Nawarangpur	1.93 (2006)	1.13 (2006)	3.06
19	Rayagada	2.00 (2006)	2.31 (2006)	4.31
20	Mayurbhanj	9.74 (2007)	2.58 (2007)	12.32
21	Phulbani	0.53 (2006)	0.65 (2001)	1.18
22	Boudh	4.64 (2008)	0.79 (2008)	5.43
23	Puri	87.37 (2001)	3.69 (2006)	91.06
24	Khurda	41.02 (2001)	1.96 (2006)	42.98
25	Nayagarh	9.31 (2001)	3.02 (2001)	12.33
26	Sambalpur	3.19 (2001)	0.58 (2001)	3.77
27	Bargarh	1.31 (2003)	0.86 (2003)	2.17
28	Deogarh	1.92 (2001)	0.76 (2001)	2.68
29	Jharsuguda	7.00 (2001)	1.76 (2001)	8.76
30	Sundargarh	0.80 (2001)	0.39 (2003)	1.19
	Total	**785.07**	**133.89**	**918.96**

From the tables it can be inferred that about 9.19 lakh hectares of cropped area are exposed to damage by flood & submergence during a period of 8 years. However the degree of crop damage greatly varies basing on the duration of submergence and intensity of flood coupled with the time of occurrence and stage of the crop.

From the above analysis is confirmed that climate shocks are affecting Odisha's economy. Experts throughout the world are assessing the diverse threats posed by climate change. Current scientific evidence points to significant impacts of climate change in the future as well as some observed early signals and impacts of climate changes in the present day. During the course of the 21st century, scientific evidence points to global-average surface temperatures are likely increasing by 2–4.5◦ C as greenhouse gas concentrations in the atmosphere increase. At the same time there will be changes in precipitation, and climate extremes such as hot days, heavy rainfall and drought are expected to increase in many areas. Thus Odisha is frequently bearing the destructive effects of these natural calamities. Further, with advance in global warming and climate change, if sea storms acquire greater destructive power as is being forecast, the state will be required to bear the burden of such storms which means devastating effects on livelihoods, ecology and economy of the state.

5. Adaptation Strategies

Prevention of these climate shocks is almost difficult. Prevention is often long term and would require integrated interventions by the state or national governments. However, some measures are to be taken up to reduce the impact of different these events. Adaptation to climate change is typically characterised as an adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts, in order to alleviate adverse impacts of change or take advantage of new opportunities. Adaptation can therefore involve both building adaptive capacity thereby increasing the ability of individuals, groups, or organisations to adapt to changes and implementing adaptation decisions, i.e. transforming that capacity into action. Both dimensions of adaptation can be implemented in preparation for, or in response to, impacts generated by a changing climate. Hence adaptation is a continuous stream of activities, actions, decisions and

attitudes that informs decisions about all aspects of life, and that reflects existing social norms and processes. Reilly and Schimmelpfenning (2000) point out that some adaptation occurs without explicit recognition of changing risk, while other adaptations incorporate specific climate information into decisions.

The major types of adaptation are:

- Reducing the sensitivity of the affected system, which can be achieved, for example, by investing in flood defenses or increased reservoir storage capacity; planting hardier crops that can withstand more climate variability; or ensuring that infrastructure in flood-prone areas is constructed to allow flooding.
- Altering the exposure of a system to the effects of climate change, which can be achieved, for example, by investing in hazard preparedness and early warnings, such as seasonal forecasts and other anticipatory actions.
- Increasing the resilience of social and ecological systems, which can be achieved through generic actions which aim to conserve resources, but also include specific measures to enable specific populations to recover from loss (Tompkins and Adger, 2004).

The major actions for adaptation in agriculture that can be undertaken are

- Technological improvement in terms of farm mechanization and introduction of hybrid and drought resistant crops
- Water management by public and private partnership for the effective use of available water resources
- Increase in irrigation facilities
- Crop diversification and crop rotation
- Crop insurance and awareness programme for information dissemination
- Climate and weather information centre at the block level for awareness of climate related events among the public
- Technical support to farmers when needed
- Research and development in agricultural innovation

6. Conclusion

It is quite clear that the growth rates of agricultural products have been highly skeptical and irregular in Odisha along with instability. This is due to either decline in yield rate or decline in area under cultivation. Further the climate shocks are affecting the agriculture in Odisha in a large extent. Thus the erratic yield rates of various crops may be attributed to bad weather, natural calamities or factors specific to the local area. Further given the combined public and private good nature of the benefits of adaptation in agriculture and related sectors, the role for public policy in tackling these problems is very important. Agricultural regions facing climate change are subject to multiple stresses and many other factors that limit the ability to adapt. Enhancing adaptive capacity, particularly that of disadvantaged rural populations, is likely to be more fruitful.

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